

Simultaneous Chandra X-ray, HST Ultraviolet, and Ulysses Radio Observations of Jupiter's Aurora

R. F. Elsner,¹ N. Lugaz,² J. H. Waite, Jr.,² T. E. Cravens,³ G. R. Gladstone,⁴ P. Ford,⁵ D. Grodent⁶, A. Bhardwaj⁷, R. J. MacDowall⁸, M. D. Desch,⁸ and T. Majeed²

¹ NASA Marshall Space Flight Center, SD 50, Huntsville, AL 35812

² Dept. of Atmospheric, Oceanic, and Space Sciences, University of Michigan, 2455 Hayward St., Ann Arbor, MI 48109-2143

³ Dept. of Physics & Astronomy, University of Kansas, Lawrence, KS 66045

⁴ Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78228-0510

⁵ Massachusetts Institute of Technology, Ctr. For Space Res., 37-635, 70 Vassar St., Cambridge, MA 02139

⁶ LPAP – Université de Liège, Institut d'Astrophysique et de Géophysique, Allée du 6 Août, 17, Liege, B-4000, Belgium

⁷ NRC Senior Resident Research Associate, NASA Marshall Space Flight Center, SD50, Huntsville, AL 35812, on leave from Space Physics Laboratory, Vikram Sarabhai Space Centre, Trivandrum, India

⁸ NASA Goddard Space Flight Center, Code 695, Greenbelt, MD 20771

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Abstract

Observations of Jupiter carried out by the Chandra ACIS-S instrument over 24-26 February, 2003, show that the auroral X-ray spectrum consists of line emission consistent with high-charge states of precipitating ions, and not a continuum as might be expected from bremsstrahlung. The part of the spectrum due to oxygen peaks around 650 eV, which indicates a high fraction of

fully-stripped oxygen in the precipitating ion flux. A combination of the OVIII emission lines at 653 eV and 774 eV, as well as the OVII emission lines at 561 eV and 666 eV, are evident in the measure auroral spectrum. There is also line emission at lower energies in the spectral region extending from 250 to 350 eV, which could be from sulfur and/or carbon. The Jovian auroral X-ray spectra are significantly different from the X-ray spectra of comets. The charge state distribution of the oxygen ions implied by the measured auroral X-ray spectra strongly suggests that, independent of the source of the energetic ions — magnetospheric or solar wind — the ions have undergone additional acceleration. This spectral evidence for ion acceleration is also consistent with the relatively high intensities of the X-rays compared to the available phase space density of the (unaccelerated) source populations of solar wind or magnetospheric ions at Jupiter, which are orders of magnitude too small to explain the observed emissions.

The Chandra X-ray observations were executed simultaneously with observations at ultraviolet wavelengths by the Hubble Space Telescope and at radio wavelengths by the Ulysses spacecraft. These additional data sets suggest that the source of the X-rays is magnetospheric in origin, and that the precipitating particles are accelerated by strong field-aligned electric fields, which simultaneously create both the several-MeV energetic ion population and the relativistic electrons observed in situ by Ulysses that are correlated with ~40 minute quasi-periodic radio outbursts.

1. Introduction

Jupiter is a powerful source of X-rays within our solar system [Bhardwaj *et al.*, 2002]. Early observations revealed both a high-latitude source of X-rays associated with Jupiter's aurora [Metzger *et al.*, 1983; Waite *et al.*, 1994] and a low-latitude source associated with particle precipitation from the radiation belts and/or scattered solar X-rays [Waite *et al.*, 1997; Maurellis